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ABSTRACT

A study explored the degree to which people can capture the meaning of logical terms, using mental imagery. It was then hypothesized that: (1) subjects generally would fail to express logical relationships accurately, and (2) abstract images would be more difficult to capture than would concrete ones. Subjects, 25 college students, were asked to form mental images of two abstract and two concrete sentences, each of which contained a logical term ("either/or," "if/then," "because," or "not") and to write a brief description of the images. These image reports were then coded and analyzed. Results tended to support the first hypothesis, with only 8% of the images reported deemed adequate in a logical sense. Data concerning the second hypothesis were more ambiguous. Concrete stimuli produced more logically appropriate images for "either/or" and "not" sentences, but abstract stimuli worked better for "if/then" and causal reasoning. (FL)

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MENTAL IMAGERY AND LOGICAL TERMS

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Paper presented to Speech Communication Association, Chicago, November 1984.

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MENTAL IMAGERY AND LOGICAL TERMS

Abstract

This study was designed to explore the degree to which people can capture the meaning of logical terms, using mental images. Subjects were given concrete and abstract sentences which contained one of four logical terms: if/then, either/or, because, and not. Subjects were asked to form a mental image of the statement, then to write down a brief description of the image. These image reports were coded, and supply the chief data for the study. The hypotheses were that people would generally fail to express the logical relationship accurately, and that abstract images would be more difficult. The first hypothesis received considerable support, as only 8% of the images were fully adequate in a logical sense. Data bearing on the second hypothesis were more ambiguous. A clear superiority for the concrete stimuli appeared for some conditions, but not all. We speculate that the occasional advantage to abstract stimuli was due to subjects' inability to carry out the experimental task.

MENTAL IMAGERY AND LOGICAL TERMS

Paivio (1971) has produced an impressive body of evidence indicating that humans think in two different modalities: the verbal and the imagic. Verbal thinking is based on words, and is therefore linear and sequential (after all, that is the way we read and hear words.) Imagic thinking, on the other hand, makes use of "mental pictures," and is nonlinear and organic. To experience this difference, try two quick thought experiments: (1) Recall the last line of the childhood prayer which begins, "Now I lay me down to sleep." (2) Form a mental picture of your office, first from the vantage point of someone entering your door, and then from the perspective of a fly in the middle of the ceiling. Nearly everyone, in order to accomplish (1), must begin with the first line of the prayer and recite all the lines to oneself until the last line is remembered. This is an example of verbal thought, and displays its unidirectional demands. In contrast, people generally feel no more strain in imagining their offices from one point than from another. An image has no special starting or ending place: it is a whole, which may be entered or used from any point.

These essential differences between verbal and imagic thought are held to have important implications for people's ability to reason logically (Hample, 1982a). Logic is word-based, and logical thought sequences are inherently directional. Therefore, verbal thought is believed to be the natural seat of logic in the human mind. Since sequences are foreign to imagic thinking, such processing is commonly described as alogical (Hample, 1982a; Kosslyn, 1980, p. 32; Wyer & Carlston, 1979, pp. 41-42).

Features of the text have a strong influence on which cognitive mode people use (Paivio, 1971). Abstract materials are normally handled in the verbal modality, and are difficult to image. Concrete words, however, can be processed either verbally or imagically. Being words, they may be handled with the usual verbal, semantic system. But because they are concrete, they can more easily be imaged, and so may also use the imagic mode. Normally, stimuli and responses are verbal, so that even if the actual processing is imagic, these concrete words must be translated back and forth from one system to the other. Thus, we say that concrete words are dual-coded.

This has several immediate implications. First, images are easier to form for concrete than verbal materials (Dominowski & Gadlin, 1968; Jorgensen & Kintsch, 1973). Second, we should expect better performance on a logical task when the stimuli are abstract than when they are concrete. Hample has performed several studies designed to demonstrate this second point. He found conflicting results, but some support for the hypothesis, with categorical syllogisms (Hample, 1982b). The facilitating effect of abstractness appears for disjunctive syllogisms, but not for hypothetical ones (Hample, 1983). Overall, the outcomes of these studies present interpretive problems, and suggest that the relation between logical performance and abstractness/concreteness is not so straightforward as was supposed.

For instance, if imagery is alogical, and if concreteness stimulates imagery, how could concreteness have improved performance on hypothetical syllogisms (Hample, 1983) and on some kinds of categorical problems (Hample, 1982b)? Perhaps images do have some logical merit.

Even Hample (1982a, p. 67) remarks that "it would be an exaggeration to say that logic has nothing to do with imaginal processing." Plausibly, people may be able to form images which somehow capture an entire logical relationship. If so, the fact that, in many situation, images are easier to handle than verbal items (e.g., Kusyszyn & Paivio, 1966; Groninger & Groninger, 1982) may explain the sometimes-advantage to concrete materials in logical problems.

Werner and Kaplan (1963, pp. 454-466) summarize a dissertation by Erle (1963) which bears on the adequacy of logical images. Erle asked 12 adults to represent several sentences having the terms "because" or "if" by forming mental images. Respondents then described their images verbally. Qualitative analyses illuminated a number of ways of thinking about causality and conditionality, but do not clearly address the question of logical adequacy.

The present study is generally patterned after Erle's, but with several important differences. More subjects are used, and the analysis will be quantitative, and designed to evaluate logical adequacy. Four important logical terms will be tested: "because," "if/then," "either/or," and "not." "Not," is of course an essential term in logic, but is commonly thought to pose special problems for nonverbal thought (e.g., Bateson, 1968). The other terms are equally important in various kinds of problems. Finally, concreteness will be systematically manipulated, to determine whether it influences the quality of specifically logical images.

Results of this preliminary study should help to evaluate these two hypotheses:

(1) Images of stimuli involving logical terms will fail to capture the meanings of those terms.

(2) Abstract logical images will be harder to form than concrete logical images.

As the reader will probably have inferred, the second hypothesis is supported by the literature on imagic v. verbal processing (though we are unaware of any study which explicitly included logical relationships within the stimuli). The first hypothesis, while it follows readily from the general dual coding theory (Paivio, 1971) and other work on imagery, is rendered somewhat doubtful by the occasional superiority of concrete over abstract materials in logical problems in several studies (Hample, 1982b; 1983).

Method

Subjects

Subjects were 25 senior communication majors enrolled in an interpersonal communication research methods course taught by one of the authors. 12 of the students were female, and 13 male. Their mean age was 21.4 years.

Procedures

Students were asked to form mental images of sentences. "Mental image" was described as "a photo in the mind's eye," and in other terms. Each student was requested to visualize a Volkswagon as an example. The class was divided in half, and sentences were read orally to them. Some oral emphasis was given to the logical terms ("if/then", "either/or", "because", and "not"), and each sentence was repeated once.

Each student responded to two abstract and two concrete sentences. 4" by 6" index cards were distributed, and students were asked to write down their image for each sentence on a card. On the first of the four cards, respondents also indicated their gender, year in school, and age. After writing descriptions of all four images, students indicated how difficult they found generating each image, using a seven point scale on which 1 was "very hard to form an image", and 7 was "very easy to form an image".

Stimuli

Eight sentences were used as stimuli. Each of the four logical terms appeared in a concrete sentence, and again in an abstract sentence. These were the stimuli used:

Abstract	Concrete
1. If universities lose too much enrollment, then they will close.	1. If a dog is well fed, then it will grow.
2. Either taxes will be raised or inflation will continue.	2. Either an exam will be given or a paper will be assigned.
3. The war was brief because one side gave up.	3. The girl was angry because the bar closed.
4. Philosophy is not the answer to the world's problems.	4. Ronald Reagan did not eat the apple.

On the average, about 3-5 minutes were required to generate and write down each image. After the cards were collected, students were debriefed and led in a discussion concerning mental imagery and digital v. analogue codes (Watzlawick, Beavin & Jackson, 1967).

Coding

The students' images were coded independently by each author, using the coding system in Figure 1. Figure 1 also reports the intercoder reliabilities, expressed either as percentage of agreement or as intercoder correlation coefficients, depending on the nature of the coding category. Reliabilities of all the items except 10 and 11 were high. Disagreements on items 1, 4, 5, 6, 7, 8, and 9 were resolved by discussion between the coders. Disagreements on the remaining items were handled by using both coders' results as separate variables in the later analysis; therefore, items 2, 3, 10 and 11 in Figure 1 are each represented with two values for each coded image.

The coding scheme in Figure 1 was designed to allow judgments of the quality of students' images, both in logical terms, and in regard to their general quality as images. Most of the items pertain to the issue of logical quality. Item 1 provides a quick assessment of whether the image allows for a complete logical expression; an image missing one or more of the main terms in the stimulus will obviously not contain all the logical meaning. Item 4 is of interest because, as we will see, some respondents represented the logical stimulus, not by imaging it, but by re-expressing it verbally, using the original logical terms. Such a response would often be coded as expressing the logical relationship on item 5, but not as doing it imagically, on item 7. Items 5 and 7 are simple yes/no judgments about whether the subject successfully expressed the logical relationship at all, and whether s/he did so imagically. Item 10 allows a slightly more refined assessment of the logical quality of successful images. Item 8 bears on the logical

quality of the image for two terms (because and if/then) which require temporal ordering. Item 8 was not coded for either/or and not.

The remaining items are intended to assess the general quality of the image qua image, without regard to its logical quality. Item 11 calls for a global judgment of the image's memorability and vividness. while items 2 and 3 asked for specific judgments about the image of both nouns in the stimulus. Items 6 and 9 allow us to pull out two particular features which bear on coherence and memorability: whether the respondent enlarges on the stimulus to make a more complete "story" out of it, and whether the image appears to be a personally meaningful one.

Data from this coding system should enable us to test the hypotheses. Data from the abstract and concrete conditions can be compared on all these items to test the second hypothesis. Settling the first hypothesis will be less clear-cut, but evidence from our coding surely will bear on the ability of our respondents to form logical images.

Results

Respondents rated the difficulty of forming each image. We performed an analysis of variance on these self-reports, and discovered main effects for both concreteness/abstractness ($F=7.482$, $df=1/91$, $p=.01$) and logical term ($F=4.046$, $df=3/91$, $p=.01$). The interaction was not significant ($F=1.591$, $df=3/91$, $p=.20$). Examination of the mean ratings reveals that the effects are these: Concrete stimuli's images were rated as easier to form than those of abstract stimuli (5.26 v. 4.14). The easiest logical terms for which subjects formed images were if/then (5.76) and because (4.80), while they experienced the most

difficulty with not (4.42) and either/or (3.82).

Several correlations yield a clue as to what criteria subjects had in mind when they were rating difficulty. Correlations of these self-reports with coders' ratings of the degree to which the image captures the logical image (item 10 in Figure 1) were insignificant (r=.06, p=.29 for coder 1, and r=.09, p=.19 for coder 2). Self-reports of difficulty do, however, correlate with the coders' ratings of general imagic quality (item 11): r=.34, p=.001 for coder 1, and r=.28, p=.002 for coder 2. The self-reports seem therefore to be related to imagery in general, but not to logical quality. This is our first indication that subjects were not particularly sensitive to the logical task they faced.

Perhaps the most striking result of the study is that subjects were generally unable to perform the experimental task. Results from our coding of several items indicate that the students were typically unsuccessful in forming accurate logical images. The sample got less than half (42%) their responses coded as expressing the logical relationship, according to item 5 results. And in many of these cases, respondents expressed the logical relation by simply repeating the key word (e.g., "because") in the account. This happened in 21% of the responses, and the probability of using the logical term explictly in the account (item 4) correlated significantly with the item 5 rating of logicality (r=.50, p=.001). Use of the logical words dodges the experimental task, since "because" (for instance) is not itself an imaginal representation.

On item 7, which asks whether the subject captured the logical relationship <u>by means of the image</u> (as opposed to, say, a simple verbal

repetition of the stimulus), respondents were coded as doing very poorly: only 8% of all the responses were judged to have represented the logical relationship appropriately with an image. Our ratings of the logicality of the images (item 10) were also low: on a 1-3 scale, coder 1 produced a mean of 1.07, and coder 2 a slightly more generous 1.16. All of these findings tend to support our first hypothesis, that people's images of stimuli involving logical terms will tend to be inadequate.

Our second hypothesis is that the images for the abstract stimuli will be more difficult to form successfully than the images for the concrete items. Several kinds of evidence bear on this hypothesis.

We conducted two separate MANOVAs, one for the logical quality of the images, and one for the imagic quality regardless of logicality. The analysis of logical quality used as dependent variables the results of items 1, 5, 7 and both coders' ratings for item 10. Independent variables for this MANOVA (as well as the other) were logical term and concreteness/abstractness. Concreteness did not have a significant effect on the combined dependent measure (approx. F (Wilk's)=1.849, p=.112). Logical term did have a significant effect (approx. F (Wilk's)=3.311, p=.001), but so did the term by concreteness interaction (approx. F (Wilk's)=4.224, p=.001). Examination of the univariate tests for the interaction disclosed significance for only two variables, item 5 (F=10.075, df=3/91, p=.001) and item 10, coder 1 (F=3.960, df=3/91, p=.01). The means for item 5 (see Table 1) indicate that concrete stimuli were more successfully imaged for either/or and not, but that abstract images tended to be better for because and if/then. Item 10

(coder 1) means show an advantage for concrete stimuli for not, an increment favoring abstract stimuli for if/then, and no difference for either/or and because. Results of this MANOVA provide support for the hypothesis in some respects, but not in others: the predicted advantage for concrete stimuli appears for not on both items 5 and 10, and for either/or on item 5. However, abstract stimuli involving the terms if/then (both items) and because (item 5 only) are more likely to be logically successful.

The MANOVA for general imaginal quality used items 2, 3, 6, 9 and both coders' item 11 as dependent measures. As in the other MANOVA, we found no significant main effect for concreteness/abstracness (approx. F (Wilk's)=1.769, p=.095), significance for logical term (approx. F (Wilk's)=2.952, p=.001) and the interaction (approx. F (Wilk's)=1.825, p=.013). Univariate tests for the interaction reveal significant effects only for item 9 (F=8.584, df=3/91, p=.001). Means for item 9 (see Table 2) show that concrete stimuli were more likely to produce a personal image for if/then, either/or and because, but that abstract stimuli's images were more personal for not. Again, we have ambivalent evidence regarding the hypothesis: the predicted concreteness advantage occurs for three of the terms, but abstract stimuli produced better images for materials including the word "not."

In addition to the univariate ANOVAs clearly authorized by the MANOVA results, we conducted two additional ANOVAs which bear on the study's hypotheses.

Using number of stimulus items mentioned in the image (item 1) as a dependent measure, we found that subjects were more likely to include

both parts of the stimulus in their images for concrete items (F=3.843, df=1/91, p=.05). The average number of stimulus items in the image was 1.70 for the concrete materials, but only 1.45 for abstract. We discovered no main effect for logical term on this item (F<1); nor was the interaction significant (F=2.036, df=3/91, p=.11). This pattern of findings tends to support the hypothesis, since it indicates that images for abstract stimuli were more likely to omit one or more of the logically essential items.

Item 7 results modify those reported above for item 5. The difference between items 5 and 7 is that 7 focuses on whether or not the logical relationship is expressed by means of an image. A subject could (and many did) express the relationship in an essentially verbal manner. Such a response would be coded as a success on item 5, but not so on 7. Analysis of variance on item 7 indicates no significant effects, either for concreteness/abstractness (F=2.218, df=1/91, p=.14), for logical term (F=1.175, df=3/91, p=.32), or for the interaction (F=2.051, df=3/91, p=.11). These findings suggest that the item 5 results are due to verbal re-expressions of the stimuli, and not to imagery.

The results as a whole have these implications for our hypotheses: The first hypothesis, that people will be generally unable to perform the logical task, is clearly supported. Only about 8% of the responses were coded as successfully capturing the logical relationship by means of the image. The second hypothesis, that concrete stimuli's images will be easier to form and more logically successful than images from abstract stimuli, is more difficult to assess. The predicted concrete advantage did occur in several respects: concrete images are more

logically appropriate for either/or and not, tend to be more personal for all the logical terms except not, and mention more of the stimulus items in general. These findings support the hypothesis. However, we found advantages for the abstract stimuli in other areas: abstract images are more logically successful for because and if/then, and are more personal (hence, we suppose, more memorable) for stimuli involving not. The complexity of our results bearing on the second hypothesis indicate that (1) concreteness/abstractness is a key variable, and (2) that the relationship between concreteness and logicality may vary from logical term to logical term.

Discussion

This study's general purpose has been to examine the degree to which logical relationships can be handled imaginally.

Perhaps our clearest result is also the most theoretically interesting. Plainly, people have great difficulty processing logical relationships in their imagic modalities. These results support Hample's (1982a) theory that, under certain conditions, inducing an audience to think imagically can make fallacies more attractive. Although we did not ask people to reason with their images in this study, the images themselves suggest nearly boundless opportunities for fallacious thinking.

Consider, for example, several of the images for because items. The abstract stimulus was "The war was brief because one side gave up." Here are several examples we collected:

(1) Mothers crying as caskets are sent home on trains. Celebrations in the streets. A thick sadness and a terrible twilight siloutte of a devasted land of the losers. Weary faces tired from their emotions, not really the physical tests endured.

(2) People throwing away their guns & fast walking away from the battle. No one really caring about who won. Everyone partying in the streets because of the peace.

One can hardly fail to notice what is missing from these images: the brevity of the war, the concession of one side, and, in short, the causality of the war's end. Both respondents (and these two were fairly typical) focused entirely on one part of the image: the war's conclusion. Though these students were supplied with (let us stipulate) an accurate assessment of causality, they did not retain it imagically. Presumably, therefore, they would not have the true causality as a resource in resisting future appeals suggesting different causes.

Images are expected to be idiosyncratic, but to be useful they must somehow link up with what they are supposed to represent. In several cases, the coders were at a loss to figure out how the images could ever make the stimulus' meaning retrievable at all. Consider some examples. Here is one for "Philosophy is not the answer to the world's problems:"

(3) I see a mad scientist arguing on national television in efforts to convince the world that science is the way to solve the world's problems.

Or, this one, for "Either taxes will be raised or inflation will continue:"

(4) I see mobs of people rallying outside courts & police

stations. They are protesting unhappiness over having no money & no jobs.

The respondent who produced (3) presumably saw science as "not philosophy," and was exploring what would solve the world's problems if philsophy cannot. But the image ends up working the other way: only a madman could claim that not-philosophy (science) will solve the world's problems. So the only conclusion which one might be tempted to draw from the image about the original stimulus (and it is invalid), is that philosophy is the answer. Image (4) is not quite so logically fatal, but it omits both the stimulus items, taxes and inflation. "No money" and "no jobs" presumably represent either taxes or inflation or both, but the relationship is impossible to extract from the image. If anything, it merges taxes and inflation, whereas the stimulus very clearly presented them as alternatives. This respondent apparently did not absorb the idea that a choice between inflation and taxes was available, and instead generated an image which reacted against both of them indiscriminately.

Though our conclusion that people are not accurate in forming images of logical relationships seems firmly established by our data, our hypothesis regarding concreteness' presumed advantage over abstract materials received uncertain support. We often found that concretness/abstractness interacted with the logical terms, producing different results for different terms. Though this mitigates against the possibility that the concreteness effect is a simple one, it should not discourage us. Each of the logical terms bears upon an important domain of argumentation, and we might sensibly wish to pursue separate

hypotheses about each kind of reasoning.

We found that concrete materials produced more logically appropriate images for either/or and not stimuli, but that abstract stimuli performed better on if/then and causal reasoning. Notice that the only temporal demands in our stimuli are for the latter two kinds of material. As we noted in the introduction to this paper, our abstract modalities ought to do better for sequential information.

But when people image, they are not supposed to be using their abstract modalities. How could an abstraction advantage carry over into imaging? The answer may well be that our respondents refused to image. In several cases, the only real evidence that what we were coding was an image, was the fact that our respondents labeled it as such. Some of the responses were highly verbal. Here are some examples for the abstract because item (the brief war) and for the abstract if/then stimulus ("If universities lose too much enrollment, then they will close"):

(5) It seems that the one side fighting should not of fought if they couldn't battle very long. When two battle each other such as a war among countries the defense backing should be considered before entering the battle. I think of a battle instead of two people just fighting.

(6) If the number of students who attend places where higher education, (namely B.A. goal oriented) is taught decreases, then these places will eventually close down because of the lack of these students.

(7) I can see many people not coming to college anymore because of

the high cost of tuition so enrollment will decline. This would lead to the school closing because their would be neither money nor students.

In these examples, the imagic quality of the students' responses is, to say the least, difficult to locate. Though there were not many examples as extreme as these, we noticed throughout our coding that resistance to the logical task often took the form of using verbalization instead of true imagery. As a matter of fact, one of the better images of the taxes-or-inflation stimulus was simply a newspaper headline. Several of the images we received involved someone saying a version of the stimulus.

Readers will recall that students' self-reports indicated that they found the concrete items generally easier to image, and that these self-reports seemed influenced by the imagery elements of the task, not the logical ones. Another interesting outcome of these self-reports was that students said that the easiest images to form were those involving the if/then and because terms; and these are exactly the conditions in which the abstract stimuli produced responses coded as more logically accurate. We speculate that one reason that we sometimes found an advantage to abstract stimuli in our results is that students found the abstract materials so hard to image that they really did not produce images at all, and instead produced an easy verbal paraphrase or elaboration. It is fairly simple to re-express the stimuli's logical features verbally, and rating these performances as successes may well have produced the results cited above, indicating an apparent advantage to abstract stimuli for if/then and because items.

We are therefore inclined to suspect that the concreteness advantage we predicted may very well occur for all the logical terms in our study, but that some sort of screening procedure may have to be used to reject pseudo-images from the data set. We were not prepared to do such screening ourselves for this study, and because of the obvious opportunity for unconscious experimenter bias to assert itself, we did not do so on a post hoc basis. However, we suggest that this refinement be added to our procedures by other researchers exploring these topics.

Conclusions

People display great difficulty in capturing logically important information in mental images. Very few of the subjects in this study were successful in generating logically candid images. Respondents reported more difficulty in forming images at all for the abstract stimuli. We found some evidence for the superiority of concrete stimuli in this task, and have speculative reason to suspect that some of the apparent advantages to abstract stimuli may be due to respondents' rejection of the experimental task.

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Figure 1

Coding System, with Reliabilities

Expressed as Percentage of Agreement or Correlation Coefficient

(91%) 1. Number of items explicitly included or clearly implied: 0,1,2.

(.94) 2. For the first-mentioned item in the stimulus, rate:
Imaged Very Poorly 1 2 3 4 5 Imaged Very Well 9=Absent

(.97) 3. For the second-mentioned item in the stimulus, rate:
Imaged Very Poorly 1 2 3 4 5 Imaged Very Well 9=Absent

(98%) 4. Was the logical term (because, if/then, either/or, not/no/n't) used explicitly? Yes No

(92%) 5. Is the logical relationship present or absent? P A
Note: Item 1 must be 2 for the relationship to be present.
Either/or requires a choice, some notion of alternatives, etc.
If/then requires time ordering and contingency of some sort.
Not requires negation, denial, destruction, etc.
Because requires time order, dependency, production, etc.

(95%) 6. Did the respondent interpolate a reason into the account in order to explain the logical relationship? Yes No

(92%) 7. Is the logical relationship <u>imaged</u> accurately? Yes No
See notes for item 5.

(84%) 8. What time ordering between the two stimulus items is expressed or implied?
0 = none or simultaneous
1 = first-mentioned item in stimulus happens first
2 = second-mentioned item in stimulus happens first

(97%) 9. Is the image <u>personal</u> (involving self, close relation, friend, etc.) or <u>impersonal</u> (not apparently involving anyone or anything personally known to the respondent)? P I

(.47) 10. Rate the degree to which the image <u>captures the logical relationship</u>: High, Medium, Low. (see notes for item 5)

(.59) 11. Rate the degree to which the image (regardless of its logical quality) is <u>vivid/memorable/concrete</u>: High, Medium, Low.

Table 1

Mean Ratings on Item 5 (with Ns)

by Concreteness/Abstractness and Logical Term

	ABSTRACT	CONCRETE
IF/THEN	1.83 (12)	1.92 (13)
EITHER/OR	1.92 (13)	1.25 (12)
BECAUSE	1.17 (12)	1.54 (13)
NOT	1.75 (12)	1.17 (12)

Note: The coding scheme was: 1=relationship present; 2=relationship absent.

Table 2

Means for Item 9 (With Ns)

By Concretness/Abstractness and Logical Term

	ABSTRACT	CONCRETE
IF/THEN	1.75 (12)	1.08 (13)
EITHER/OR	1.85 (13)	1.67 (12)
BECAUSE	2.00 (12)	1.92 (13)
NOT	1.67 (12)	2.00 (12)

Note. Coding: 1=Personal; 2=Impersonal

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